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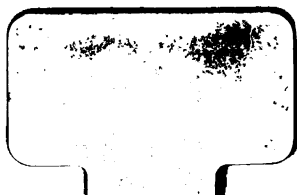
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ON
SIR CHARLES BELL'S RESEARCHES
IN THE
NERVOUS SYSTEM.



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NOTE.

IN explanation of the form in which this Essay is offered to the public, it may be stated, that it is a reprint of one appended to a posthumous edition of "THE ANATOMY AND PHILOSOPHY OF EXPRESSION, AS CONNECTED WITH THE FINE ARTS, by SIR CHARLES BELL."

I have thought the present a fit occasion to give a more detailed account of the author's discoveries in the Nervous System, than might seem called for to illustrate the subjects treated in that Work; and in pursuance of the desire to extend a knowledge of his services to science, beyond his own Profession, I have avoided as much as possible the use of technical phrases.

A. S.

ON

THE NERVOUS SYSTEM.

IN many parts of this work references are made to an Essay upon the Nervous System ; and the last edition contained such an essay. But on examining the copy intended for the present edition, it was found that the author had drawn his pen through the essay, and had not composed another to supply its place. It cannot be doubted that he intended to reconstruct that part of the work ; and as some account of his observations on the Nervous System, which bear upon the questions discussed in the volume, may be interesting, I have been requested to give a short review of his opinions. I enter upon the task with much diffidence.

It is stated, in various parts of the Essays, that a distinct Class of Nerves is provided, in the human body, for controlling the organ of Respiration ; and that it is that class which is principally affected by passion and emotion, so as to give rise to the phenomena of Expression.

In Man, the organ of Breathing is constructed in such a manner, that, besides ministering to the oxygenation of the blood, its primary office in the economy, it is the instrument of Voice

and of Expression,—two properties which bear relation to his Intellectual nature. In order to adapt the organ to these endowments, it is necessary that the mechanism should have a form and arrangement distinct from that in the lower animals, where it serves for purifying the blood alone; and as a correspondence always exists between the structure of the moving parts of the frame, and the nervous system, which regulates their actions, the change in the construction of the organ is accompanied with a change in the arrangement of the nerves. Accordingly, by comparing the nervous system in the inferior animals, with its order and distribution in man, the author found that a distinct class of nerves is appropriated, in the human frame, to the organ of Respiration: and to that class he gave the name *Respiratory Nerves*.

But that conclusion was not arrived at till many other important observations had been previously made on the functions of the Nervous System. Medical science has been indebted to the author of this volume for improvements in our knowledge of the Nerves, only to be compared, for their extent and value, with those introduced by Harvey, by his discovery of the Circulation of the Blood. Although no parts of the living body have excited greater interest, since anatomy was first studied, than the Brain and the Nerves, yet when Sir Charles Bell entered upon his researches into the subject, he found it involved in so much confusion, and surrounded by so many difficulties apparently insurmountable, that physiologists had almost ceased to prosecute it. Errors on points which bore on the first elements of the inquiry, had taken deep root. He succeeded in removing these errors, and in establishing a new principle of investigation. By adopting that principle as his guide, he was rewarded not only by making discoveries of the utmost value to medicine, but by communicating a fresh impulse to the labours of other physiologists in the same field.

The error which formerly prevailed, and had the greatest effect in retarding improvement, was this:—It was taken for granted that all parts of the nervous system had certain general properties belonging to them in common; so that all were

considered alike in function. The Brain, including the Spinal Marrow, was looked upon as a common store, from which certain powers, such as that of motion, were issued to the body, and into which others, such as sensation, were received, the nerves being regarded as the conductors; and, in conformity with that view, it was further supposed that any part of the brain, or any single nerve, had equal power with all the others of bestowing the numerous properties commonly assigned to the nervous system. For the sake of illustration, let us take the nerves of the extremities, which arise from the spinal marrow. It was conceived that these nerves were all simple in structure, and that, nevertheless, they had the double property of conveying the power of motion and of sensation to the limbs: and the spinal marrow, being regarded as a prolongation of the Brain, was believed to transmit the powers of motion and of sensation along the nerves, by all its parts promiscuously.

Certain facts probably diverted the minds of physiologists from perceiving the correct views. For example, when the structure of a Nerve is examined, it is found to consist of a number of distinct fibrils, like threads, laid parallel, connected loosely together, and contained in a common sheath; and however narrowly the fibrils are inspected, it is impossible to perceive any difference between them; all are exactly alike in size, colour, and consistence. This similarity of structure, it may be supposed, would lead to the inference, that the functions of the fibrils were the same. Then, as to the Brain; although subdivided into several masses of different forms and textures, which give the appearance at first sight of its being composed of separate organs, yet a remarkable uniformity prevails in its general structure; the distinct substances of which it consists (the medullary and cineritious) are so intermingled and diffused, that it seems unavoidable to conclude that its powers are held in common, and are exercised by a combined operation of all its component parts. Again, the phenomena of certain diseases and accidents would probably give strength to the mistaken views. When a person is wounded in the leg, and a principal nerve cut across, the lower part of the limb, isolated from the brain, is

deprived both of motion and sensation. If the spinal marrow be crushed, or disorganised by disease, so that the communication between the brain and the parts beyond the seat of injury, is destroyed, total paralysis ensues; that is, the limbs lose both motion and sensation. When a man is struck down by apoplexy, owing to sudden effusion of blood into the brain from a ruptured vessel, he is deprived instantaneously of both motion and sensation. These occurrences, met with daily, would naturally lead to the belief that sensation and motion were inseparably united in all the different parts of the nervous system; and when it was imagined that two such distinct functions could belong to the same part, it would not be inconsistent to believe that other powers could be combined with them.

But Sir Charles Bell had not long commenced his investigations, when it occurred to him that it was contrary to reason to suppose that two functions so essentially distinct from each other as motion and sensation, could belong to the same nerve. Let us consider the direction in which the nervous agency which gives rise to motion, must necessarily be conveyed along a nerve to produce muscular contraction. As the volition originates in the brain, and the force, whatever it is, which acts through the nerve must be propagated to the muscle, it is obvious that the force will proceed *outwardly*, or centrifugally. But when a sensation is felt, as the effect must be produced by an impression made upon the extremity of the nerve expanded on the skin, and conveyed to the sensorium, it follows that the course of the nervous agency must be *inwardly*, or centripetally. Hence the force which causes muscular contraction passes along a nerve in one direction, while that which causes sensation goes in a contrary direction: and it is inconsistent to suppose that the same nerve, or the same portion of the nervous centres, could minister to both functions at once.

The fundamental principle of the author's discoveries was originally announced in nearly the following terms:—The nerves of the body possess distinct and appropriate functions, corresponding with the parts of the brain and spinal marrow with

which they are connected at their *roots*; and when a nerve, which appears simple, is found to bestow more than one endowment, it is a sign that that nerve has more than one origin from the brain, and consists in reality of several nerves joined together.

The mode by which this principle was demonstrated and established to be a law in physiology, was as follows :—

The author first directed his attention to the nerves of the Organs of the Senses. These nerves were formerly conceived to be so closely allied to each other, that their functions were regarded rather as modifications of one common property, than as distinct and specific. Thus it was supposed that the nerve of one organ of sense could be the substitute for the nerve of another, if transposed to that organ. For example, it was believed that the optic nerve, on which vision depends, could bestow sensation or pain, like a nerve of the skin; and *vice versâ*. But the author proved these opinions to be incorrect. He showed that each nerve of sense is limited to receiving a distinct and appropriate impression; that the nerve of vision can only give ideas of light and colour;* the nerve of hearing, impressions of sound; the nerve of smelling, the perception of odours; and so on. He further showed that these special properties depended on each of the nerves of sense taking its rise from a distinct portion of the brain, provided for receiving its own peculiar impression. This fact could not be easily demonstrated by referring to the human brain alone, where, owing to the organs of sense and the intellectual capacities related to them, being in their highest state of development, the structure is very complex; but the point could be satisfactorily proved with the assistance of comparative anatomy. When we examine the inferior classes of

* He illustrated this fact in the following manner. Pressure applied to the surface of the eye, between the eyelids, gives rise to pain more acute than that felt in the skin generally, but still of a similar kind; a sense of touch. But pressure applied to the side of the eye, so as to affect the retina within, produces the appearance of a halo of variously coloured light before the eye, or a totally different kind of sense from touch. In couching for cataract, when the needle pierces the outer part of the eye, it gives rise to pain,—to a sensation like that of pricking the skin; when it enters more deeply and transfixes the retina, it gives rise to an appearance like that of a spark of fire, or a sense of light and colour.

animals, we find that those lowest in the scale do not possess the same number of organs of sense which belong to the higher; on the contrary, the organs are bestowed gradually, one after another, in correspondence with the progressive advancement of the creatures in the scale of animal existence. As new organs are added, appropriate nerves appear, which communicate with the central part of the nervous system of the animal, analogous to the brain. That elementary brain consists, at first, of mere swellings, or accumulations of nervous substance, called "ganglions," collected about the mouth: and it is observed that, according as additional organs of sense, with their nerves, are introduced, new ganglions make their appearance; for the purpose, as it is reasonably concluded, of ministering to the new species of sense conferred on the animal. In proportion as the organization approaches in resemblance to that of man, the ganglions enlarge, coalesce, and become changed in form, so as to be distinguished with difficulty from each other: but they continue, even in the highest animals, to be called after the organs of sense over which they are supposed to preside; hence they get the names of Optic ganglions or lobes, Olfactory lobes, Auditory lobes, &c. Such was the first step taken by the author, to show that the nerves possess distinct functions; and that they obtain these from being connected with subdivisions of the brain, which themselves possess distinct endowments.

The next stage in his progress was marked by more striking results. His object was now to explain how the nerves, known to bestow Motor power and Sensation conjointly, are endowed with that double property.

By far the greatest number of the nerves which supply the body generally, bestow motion and sensation conjointly, and arise from the Spinal Marrow. To ascertain the source of this double power possessed by the Spinal nerves, the author proceeded as follows. He took one of them, for example, a nerve of the arm; and, tracing it from the arm towards its origin in the spinal marrow, he observed that as it approached that organ, it subdivided into two parts, called its roots—and that one of the roots entered a division of the nervous substance of the spinal marrow distinct

from that with which the other was connected; one root being further distinguished by having a swelling upon it, termed a ganglion.

That such was the mode of origin of all the spinal nerves, had long been well known to anatomists; yet no physiological conclusion had been drawn from it. But, following the principle which guided him in his researches, the author was led to suppose that roots, which thus proceeded from distinct portions of the spinal marrow, would possess distinct endowments. He therefore inferred, that one of the roots might be that which gave *motion*, while the other might be that which gave *sensation*; and, assuming this view to be correct, he further supposed, that the reason why a spinal nerve possessed both motion and sensation was, that the nerve was in reality double, being compounded of fibrils from two distinct roots.

Accordingly, he proceeded to verify his opinion by experiments made directly upon the roots of the spinal nerves, and also by observations and experiments on nerves of the Brain, some of which resemble the spinal nerves in structure, while others differ from them. Following that course of investigation, he proved by indisputable evidence,—that the root which arises from the posterior division of the spinal marrow, and has a ganglion upon it, bestows sensation alone; and that the root which comes from the anterior division, gives motion alone. Thus he established, for the first time, that nerves of Sensation are distinct from nerves of Motion. He also showed beyond a doubt, that it is because the spinal nerves are compound in structure, consisting of fibrils of Motion bound up with fibrils of Sensation, that they have the power of conferring these two properties conjointly.

It has just been stated, that to assist him in drawing his conclusions as to the distinct functions of the roots of the spinal nerves the author had recourse to observations and experiments on the nerves of the Brain: I may therefore describe shortly the results of his inquiries into the distinction between the motor and sensitive nerves of that organ.

With one exception, all the nerves which arise from the Brain, and issue from the skull to supply different parts of the Head, instead of having, like the spinal nerves, double roots, have single

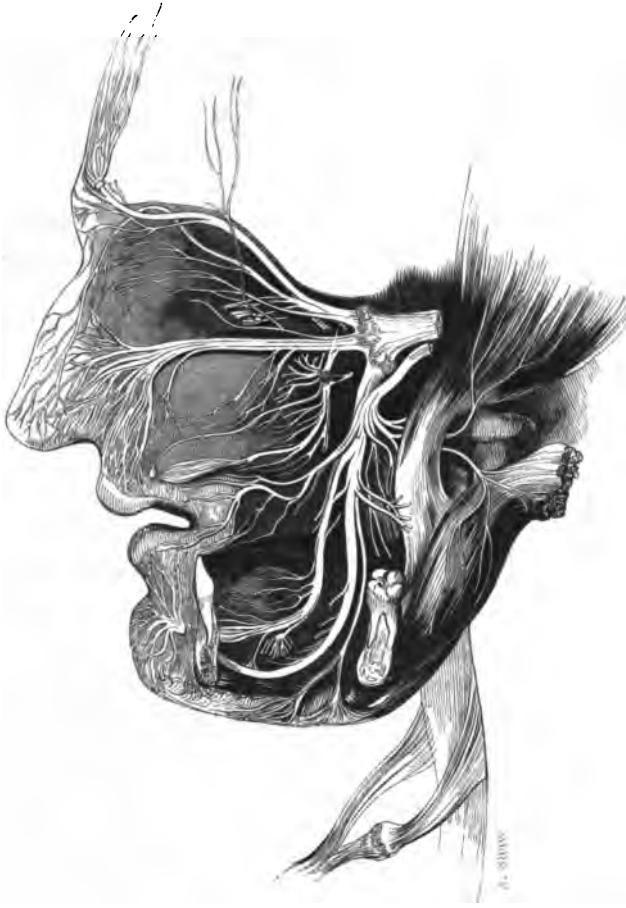
roots. A series of these single-rooted nerves arises in a continuous line from a prolongation into the brain of that division or tract of the spinal marrow, which gives off the anterior or motor roots of the spinal nerves.

The nerve which forms the exception, is the "Fifth" nerve, as it is termed. Previous to the author's investigations, the anatomy of the roots of that nerve, although correctly described in some works, had attracted no particular attention; and the most important points connected with it, were commonly passed over unnoticed. The author observed that the Fifth is remarkable among the nerves of the Brain, as alone having a double origin, like the nerves of the Spinal Marrow; and that, while one root arises from the continued tract of the spinal marrow which gives off the motor roots, the other, on which, as in the posterior roots of the spinal nerves, there is a ganglion, penetrates to a considerable depth in order to arise from the tract which sends off the posterior, or sensitive roots.

First, in regard to the experiments on nerves which arise by single roots from the brain. The nerve first selected to illustrate the functions of that series, was the one which passes to the Tongue, and is called the "Ninth." Arising from the division of the spinal marrow which gives off the anterior roots, just where that division begins to unite with the Brain, at the top of the spinal marrow, the Ninth cerebral nerve may be regarded, in its anatomical structure, as an anterior root of a spinal nerve, not joined by any posterior root. The nerve, having come off thus simply, passes out immediately, through an appropriate hole in the base of the skull, and without being joined by the fibrils of any other nerve, is distributed to the Tongue. In its passage to the tongue, it avoids going to the surface, endowed with sensibility; and exhausts all its branches in supplying the various muscles which move the organ. When this nerve was cut across in experiment, it was found that the tongue was instantaneously deprived of the power of *motion*: but the sensibility was unimpaired. It was accordingly proved that as the Ninth resembles the anterior roots of the spinal nerves in its mode of origin, it resembles those roots in function, and is exclusively a Motor nerve.

Next, in regard to the experiments on the double-rooted nerve,

the "Fifth." It will be understood from the Plan, that although this nerve resembles the spinal nerves, in the general structure of its



roots, one of them, the ganglionic, (corresponding with the posterior spinal roots), is greatly larger than the root without a ganglion. It may also be seen, that shortly after its origin, the whole nerve subdivides into three great trunks, which ramify over the entire head; and that the smaller root joins only one of the trunks, called the third or inferior maxillary, which supplies the lower

part of the face, and the muscles of the jaws. Hence the first and second great branches are simple in structure, being formed entirely of fibrils from the larger, or ganglionic, root; while the third is in part compound, from containing fibrils of the lesser root.

Referring to Plate IV., it may be observed that two large branches, one above and the other below the orbit, marked respectively I. and II., issue from the bones of the face to go to parts already abundantly supplied by another nerve, the portio dura: these are branches, as may be seen in the Plan, of the first two trunks of the fifth, derived from the ganglionic root alone. Now it was found that when these branches, called the supra-orbitary and infra-orbitary nerves, were exposed in a living animal, it gave the most acute pain to prick or squeeze them; and when they were cut across, the whole surface of the face to which they are sent, was deprived instantaneously of sensation; so entirely was sensation destroyed that the skin could be cut or pinched without the animal being conscious of the injury—without its wincing; and yet the motion of the parts was perfectly retained. Again, when the third or inferior maxillary trunk, composed of the two roots conjoined, was similarly exposed, and cut across between the brain and the point of union of the roots, pain was experienced in the operation, and the parts to which it is sent were deprived of sensation; but an additional effect was produced—the muscles of the jaws, to which the fibrils of the smaller root go, were paralysed. Hence the conclusion was obvious, that the larger root of the fifth nerve is endowed with Sensation, and the smaller with Motion; and that it is only where fibrils of the two roots are combined, that the nerve can give both properties at once. Hence, also, confirmation was given to the deductions drawn from the experiments on the roots of the Spinal nerves; the root of the Fifth cerebral nerve, analogous in origin and structure to the posterior roots of the spinal nerves, having been shown to bestow Sensation, was an additional proof that the function of the posterior spinal roots was to confer Sensation: and the root of the Fifth, analogous to the anterior roots of the spinal nerves, having been shown to bestow Motion, was an additional proof that the function of the anterior spinal roots was to confer Motion.

The author next selected for experiment the "Facial" nerve, or *Portio Dura*, which springs from a part of the brain distinct from that which gives origin to the ninth or fifth. This nerve arises by a simple root, and, without mixing its fibrils with those of any other, appears externally before the ear, as represented by A in Plate IV., and is distributed to the face. It had been hitherto believed that the portio dura was capable of bestowing both motion and sensation. But the author proved that this nerve was limited to giving motor power. By making a small incision through the skin, not larger than that for bleeding, he exposed the nerve in a monkey,—an animal which he considered better adapted than any other for the experiment, owing to the well-known mobility and activity of its features: when the nerve was laid bare and cut, the motions of the corresponding side of the countenance were at once and entirely extinguished; but the sensibility was unimpaired. It was even observed, as an additional proof that sensation does not depend upon the portio dura, that the animal manifested no signs of pain during the act of cutting it through, or pinching it.

It will be admitted that the facts and reasoning now brought forward, were alone sufficient to establish the truth of the general proposition—That nerves of Sensation are distinct from nerves of Motion: and that to different parts of the Brain and Spinal Marrow, belong distinct and appropriate endowments. But additional proofs still more convincing and interesting were soon obtained, by observing the effects of disease in the nervous system of Man himself. Numerous cases presented themselves where morbid changes in the structure of the Brain, Spinal Marrow, or Roots of the nerves, in man, gave rise to phenomena similar to those which follow experiments on the lower animals.*

For example, tumours sometimes grow within the vertebral canal, where the spinal marrow is lodged, and develop themselves in such a manner as to destroy one set of the roots of the spinal nerves, without involving the other: in these cases, only one function of the nerves is lost: if the anterior roots be affected,

* The cases referred to were recorded chiefly by the author's zealous assistant in these pursuits, Mr. John Shaw.

there is loss of motion ; if the posterior, there is loss of sensation ; and the patient is in the singular condition of having feeling in the limb, although he cannot move it ; or he may be able to move it, and have no feeling. Cases of a similar kind were met with more frequently in the face. Owing to the portio dura, and fifth nerve, which supply the face, arising from parts of the brain at a distance from each other, and the one taking a circuitous course apart from the other, disease often affects one nerve and destroys its function, without reaching the other. In such cases, when the portio dura is affected, the muscles of the face are deprived of motion ; the patient can no longer knit his brows, close his eyelids, inflate his nostril, or hold anything between his lips ; expression is entirely lost, and, owing to the muscles of the sound side dragging the paralysed cheek and lips towards them, the face is distorted ; but there is no diminution of sensibility in the half of the face thus completely deprived of motion.* But when the branches of the fifth nerve, which emerge upon the face, and arise from the larger root alone, are affected, sensation is entirely lost, while motion is unimpaired. For example, the surface of the eye, supplied by superficial branches of the fifth, and a part so exquisitely sensible that if a fine hair touches it there will be severe pain and spasm of the eyelids, may, when the nerve is destroyed, be rudely pressed with the finger, and the patient will nevertheless be unconscious of pain ; or if the surface be inflamed,†

* And it may be added, that no pain attends the loss of function. Patients are seldom aware of their face having become paralysed, until told by a friend, or it has been observed by themselves in the mirror. That is, the nerve, although formerly conceived to be one of the most exquisitely sensitive parts of the body, undergoes a process of disorganization sufficient to deprive it of its function, and yet the patient suffers no pain. This is accounted for by the portio dura being simply a nerve of motion, and having no power of bestowing sensation, or of giving pain.

† Loss of sensation in the eye, from disease affecting the ophthalmic branches of the fifth, is often followed by inflammation, which terminates in the destruction of the organ. The explanation is this ; the eye being deprived of its important guardian, the sensibility, which induces not only winking, but other efforts, to protect the tender surface from injury, dust, and other irritating particles, insensibly lodge beneath the eyelids, and without causing pain, set up violent inflammatory action. Cases are sometimes met with, where the surface of the eye has lost sensation, but where (owing to another nerve, the third, being also affected)

and it be necessary to scarify it with the point of the lancet, in order to withdraw blood, the patient will submit to the operation without pain, and without even winking, although the eyelids retain their power of closing, through the portio dura. It is from a morbid condition of one or other of the branches of the fifth, that the excruciating paroxysms of pain in that dreadful disorder, *tic-douloureux*, are produced. Should the disease which affects the nerve be situated close to its origin, so as to include both roots, then motion will be lost, as well as sensation; and not only will all the surfaces of the head which are supplied by the larger sensitive root be deprived of sensation, but the muscles of the jaws supplied by the lesser root will be paralysed: so that the patient, in eating, will neither be sensible of the presence of the food in the affected side of his mouth, nor be able to chew it.

From such examples as the above, some idea may be formed of the benefits conferred upon medical science by the discoveries in the nervous system thus shortly described. While it continued to be believed that every nerve, from whatever part it came, had the same functions, and that the different divisions of the brain and spinal marrow were alike, it followed that, when a case occurred of partial loss of sensation or of motion in any part of the body, the physician was led to conclude that disease had commenced in the brain; and his treatment was conducted on that supposition. But when it was proved that the nerves had distinct endowments, it was readily understood that the partial loss, whether of motion or sensation, might depend on an affection of the nerves after they had left the brain, and were external to the skull, and consequently, that instead of the symptoms indicating a serious, or perhaps fatal disease of the brain, they might point to a comparatively harmless disorder. In short, the knowledge now acquired of the nervous system lends, every day, the most valuable aid to the practitioner; it gives him means, not formerly in his power, of exploring disease, and of tracing it along the nerves to the precise spot where it is situated.

the upper eyelid has permanently dropped, so as to cover the eye, and defend it from injury: in these cases, inflammation does not occur, and the eye preserves its transparency.

On the Classification of the Nerves into the "Original" and "Respiratory" Systems.

When the author had established the existence of the important distinctions between the nerves of the cerebro-spinal system,* just pointed out, it soon became apparent that other questions remained to be solved concerning them. Having been led, in following the principle of his researches, to view the different modes in which the nerves arise from distinct subdivisions of the central organs, as indicating a diversity of function, he was forcibly struck by observing certain peculiarities in the origins and mode of distribution of particular groups of nerves. With the object of ascertaining whether these anatomical differences pointed to further differences of function, he proceeded, first, to examine the various parts of the body to which the nerves thus coming from distinct divisions of the brain and spinal marrow, are sent; and, then, to compare the actions and uses of such parts with each other.

When we take a general survey of the nerves of the human body (excluding, for the present, the nerves of the Organs of the Senses, and the Sympathetic system), we remark that there is one extensive series—so large that it embraces nearly all the nerves together—distinguished by the regularity and symmetry with which they are given off and pass to their destinations; while there is a second series, arising from a different part of the nervous centres, remarkable for their partial and irregular distribution.

The first class consists principally of the Spinal Nerves. Passing off from the whole length of the Spinal Marrow, at intervals of about an inch from each other, these nerves go in regular succession to the back of the head, the neck, the upper extremities, the whole trunk, and the lower extremities; and as each nerve is composed of two roots, one for motion and the other sensation, they bestow these double properties wherever they are sent. To this extensive

* The *cerebro-spinal* nerves include all those which arise from the Brain and Spinal Marrow. They are so called in contradistinction to the "Sympathetic" system, which consists of a series of nerves and ganglions distributed to the viscera of the chest and abdomen, and in many important points differing from them.

series must be added the Fifth cerebral nerve, which both in structure and function, as it has been already shown, is a spinal nerve; by its larger root it confers sensation on all parts of the head not supplied by the superior spinal nerves; and by its lesser root it gives the power of motion to a limited set of muscles, viz., those by which *mastication* is performed.

As to the second class, they arise near the point of union of the brain and spinal marrow, from a comparatively circumscribed portion of cerebral structure; the tract or division of nervous substance from which they originate, is distinct from those which give off the roots of the spinal nerves and fifth cerebral nerve; and in passing out to the body, they course in a radiating manner to parts of the head, neck, and chest, where nerves of the former class are already plentifully distributed. When we examine the structures thus supplied, we perceive that they enter into the formation of the organ of Respiration.

Here, then, a great question is presented for solution.—What is the particular character of the organs superintended by the first class, distinguishing them from the organ of Breathing supplied by the second class; or which will account for the former organs being supplied by a series of nerves so regular in their origins and distribution, and so widely extended, as the spinal nerves and fifth cerebral nerve, while the respiratory organ is provided with an appropriate set of nerves, comparatively few in number, and differing in several anatomical features from the others?

To solve this problem, the author found it necessary to call in the aid of comparative anatomy, and to take a general survey of the nervous system as it is presented in the whole animal kingdom. It is known that in all living animals, from the lowest to the highest, an analogy exists in the structure of their bodies, so that Man, and all animals below him, have certain organs in common. That being the case, the author expected to find that in the nervous system, which controls those organs, there would be a corresponding commonness of character visible in the whole animal kingdom. But again, as in the various organs composing the body a gradual process of development takes place, so that the organization of each rises in perfection in

proportion as animals ascend in the scale; and as in some particular parts the mechanism undergoes material changes, giving rise to a totally new arrangement of the structures, he thought it reasonable to expect that corresponding modifications would be introduced into the nervous system, to adapt it to the new construction of such parts.

Proceeding on that view, he observed that the numerous members of the body which are supplied by the Spinal Nerves and Fifth cerebral nerve, form together a system, which, as regards the uses they serve in the economy, presents a remarkable uniformity throughout the whole animal kingdom. But in the organ of Respiration, supplied by the other set of nerves, a striking difference exists; the apparatus of Breathing, in the lowest animals, is applied exclusively to oxygenating the Blood; its mechanism is adapted to no other office: while in the higher animals, although it continues to execute that necessary function of purifying the blood, it has a new and distinct office superadded to it; its mechanism is altered and arranged in such a manner as to adapt it to be the organ of Voice; and in Man it is moreover the essential part of the organ of Speech and Expression.

From these considerations the author was led to conclude:—First, That the class of Spinal Nerves and Fifth cerebral nerve represents in Man a system which exists, under different phases, in every animal, and he called it the “Original” class: Secondly, That the nerves of the organ of Respiration are a new system, introduced in correspondence with changes which take place in the development of that organ, as it becomes adapted to Voice, Speech and Expression, in Man; and he called the nerves the “Superadded,” or “Respiratory” class.

To give a full exposition of the grounds on which the above classification is founded, would occupy more space than my limits allow. But I may point out briefly some of the leading facts on which it is based.

First, as to the statement, That the spinal nerves and fifth cerebral nerve, called the “Original” class, superintend organs common to the lowest animals and Man. In order to judge

of the correctness of this view, it is necessary to inquire, What organs are possessed alike by Man and all the inferior animals?

To give the most comprehensive answer to that question, the best mode is to consider—What are the organs that distinguish a member of the Animal from one of the Vegetable kingdom? By thus going to the bottom of the scale of living beings, and observing what instruments are essential for the existence of the animal of simplest structure, as well as of Man, and then taking into view the nerves required for controlling such parts, we shall arrive at a knowledge of the nervous system in its “Original,” or least developed condition; and by tracing both the organs and the nerves upwards to Man, we shall be able to judge of the persistence of the class, through the whole animal kingdom.

When we compare Animals and Vegetables together, we find that they are not so distantly related to each other as might at first be thought. Indeed, some animals, living on the confines between the two kingdoms, bear so close a resemblance to plants, and plants to animals, that zoologists often meet with difficulties in deciding whose subjects they are. But if we take a general principle for our guidance, and disregard these approximations, (for in the works of Nature there are no sudden, trenchant divisions,—she never arranges the objects of creation in squares, circles, or parallelograms; but proceeds, even in her progress from the inorganic to the organic world, by slow, uniform gradations,) we shall find that the Animal possesses organs essentially distinct from the Vegetable.

The organs *common* to the vegetable and animal, are those connected with the nourishment, growth, and reproduction of their structures. Thus, a plant imbibes nutritious matters from the earth; circulates that matter, as sap, along the branches and leaves; the sap is subject to a process of purification similar to that effected upon the blood of animals, by the lungs; it has, besides, organs, like secreting glands, for eliminating various substances from the sap. All those organs are analogous to the parts in the animal frame which serve for digestion, assimilation, oxygenation of the blood, secretion, excretion, &c. It is not,

therefore, among them, that we look for distinctive characters between Vegetables and Animals.

The difference will be found when we consider, that a plant is *motionless*—is a fixture to the part of the earth where it was originally sown, and obtains its nourishment by the very roots which fix it to the soil; while an animal, on the contrary, is *locomotive*, and must shift from spot to spot, in quest of nutriment.

Here, then, is the great and prominent distinction between a member of the vegetable and of the animal kingdom. The one is stationary; the other endowed with spontaneous motion. To ascertain, therefore, what are the characteristic, distinctive parts of an Animal body, we have to inquire—What organs must be supplied to adapt it to move from place to place in search of food, and to enable it when it has reached its food, to seize and appropriate it?

The First set of organs which an animal will require, will be, organs of *Locomotion* or progression; in other words, parts analogous to our limbs; if the creature be aquatic, they may be fins, or paddles; if it move in the air, they may be wings; if it inhabit dry land, they may be extremities and feet. The Second will be instruments which the animal may put forth, as we do our hands, to seize and secure the objects of nourishment; and they may be presented under various forms, as tentacles, paws armed with claws, projecting muzzles with teeth of peculiar shape: these are the *Prehensile* organs. The Third will be a *Mouth*, provided with appendages more or less resembling teeth, for dividing and triturating the food, and preparing it for passing along the gullet to the stomach. The Fourth will be organs capable of regulating the combined machinery of the body; that is, parts endowed with the power of initiating motion, and senses to guide the movements of the animal; in other words a *Nervous System*, consisting of nerves of motion, nerves of sense, and a sensorium analogous to the brain.

If we take a general survey of the animal kingdom, we shall find that every living being, whatever may be its place in the scale, possesses a representative, of one kind or other, of all the organs just enumerated. It is true that their structure, in the lowest, is greatly varied; in many, the signs of affinity to vegetables obscure their proper character; in others, the organs

serving for distinct purposes are more or less fused into each other, so as to be distinguished with difficulty; again, we meet with infinitely varied modifications in the mechanism of the same organs, to accommodate them to the innumerable different modes by which animals obtain their food: yet from the lowest animal inhabiting a stagnant pool, up to Man, one great but simple plan of formation is adhered to.

We may now perceive how the author came to believe, that the spinal nerves and fifth cerebral nerve, in Man, is a class common to all grades of the animal kingdom. Let me recapitulate the organs to which the nerves of that class are sent. 1st. The spinal nerves supply the Lower Extremities—the organs of progression in man, corresponding with those members by which other animals move from place to place in search of food: 2ndly, they are sent to the Upper Extremities, the arm and hand—the instruments of prehension in man, analogous to those organs by which the inferior animals seize and secure objects of nourishment: 3rdly, the branches of the motor root of the fifth cerebral nerve are distributed to the muscles of the Jaws—the manducatory organ—corresponding with the oral aperture of the lower animals, where food is delayed and submitted to trituration, previous to being swallowed and passed into the stomach. Finally, this system supplies nerves to the two organs of sense which are most essential for guiding the movements of an animal in search of nourishment: it gives the nerves of Touch, and of Taste.*

Secondly; as to the class of "Respiratory" nerves. It has been stated generally that, according to the views of the author, this is a superadded system, found only in the higher animals; and that it is introduced in correspondence with the gradual

* As it is by the sense of Taste, combined with touch, that animals distinguish their food, we can understand why the nerve of taste—the Gustatory branch of the fifth cerebral nerve—should be included in a system, common to all members of the animal kingdom, found in the earliest period of animal development, as in the latest. It has been stated before (p. 6), that the other senses, viz., seeing, hearing, and smelling, are bestowed upon animals, one after the other, according as they rise in the scale, and their organization becomes adapted to the possession of such additional senses. That may explain why the optic, auditory, and olfactory nerves should have distinct origins from the brain.

changes which the organ of breathing undergoes in the animal kingdom, as it becomes developed and adapted to Voice, in Man. To comprehend this view, we may begin by taking a general survey of the apparatus for respiration, as presented in the lowest and the highest animals; and then consider what additional nerves will be required to regulate the mechanism, in Man.

To follow the short description of the development that I am about to give, it may be of advantage to consider, at the outset,—What are the conditions required in the organ of respiration, to accommodate it to produce Voice, besides carrying on its primary and ordinary function of oxygenating the blood?

The first thing is, that the air, with which the blood to be purified is brought in contact, shall be collected within a partially closed cavity; and that the walls of that cavity shall be capable of contracting on the volume of air, so as to expel it with an impetus sufficiently strong to produce vibrations, and thus give rise to sound. The second essential thing is, that a tube, or windpipe, shall communicate between the cavity and the external air; and that connected with that tube, there shall be an appropriate apparatus for varying and modulating the sounds produced by the expulsion of air through the tube. This is the simplest view of an organ of Voice, such as belongs to Man.

But in the lowest animals, we find no vestige of such a structure. The air which oxygenates the blood, instead of being drawn into the interior of the body, exercises its influence on the blood from without—that is, by coming in contact with the exterior surface of the animal; and there is no provision connected with the organ of breathing, for producing sound. In the whole extent of comparative anatomy, so fertile in subjects calculated to inspire admiration, there is nothing which raises that feeling more, than to trace the series of simple changes which gradually take place in different animals, as they ascend in the animal scale, and to observe how the air, applied, at first, to parts situated externally, is at length conducted into the interior of the body, there to be partially closed in, and made available for producing Voice and Articulate Language, in addition to purifying the blood.

In the inferior animals which are only a grade above Vegetables,

no distinct respiratory organ exists. That deficiency corresponds with the absence of a system of vessels for circulating the blood in these creatures. The fluids obtained by assimilation of the food, and representing blood, are diffused through the cellular structure of the animal's body; and it is simply by the air being brought in contact with the integument, that a process of oxygenation, analogous to what takes place in the lungs of the higher animals, is effected: so that the mode of purification of the fluids in animals at the bottom of the scale, differs but little from that in vegetables. As soon as distinct tubes are formed for circulating the nutrient fluids (scarcely to be called blood at that early period) through the body, traces are perceived of a respiratory organ. A congeries of vessels directing their course to a particular spot, indicates that the apparatus for respiration is situated at that part: but we find as yet nothing approximating in appearance to Lungs. The animals referred to live in the water: and all that can be recognized as a respiratory organ, is a set of loose fringes, or tufts, formed by duplications, or prolongations, of the integuments. By floating freely in the water, these tufts expose the blood circulating in them to the action of the air with which the water is charged, in a more effectual manner than can be done by the integument generally. As the circulating system becomes more distinct, the fringes are exchanged for small sacs within the animal, formed by the integument folded inwards upon itself, and open for the ingress and egress of water. These pouches are, at first, mere shallow cavities; but as the organization advances, their lining membranes, on which the blood-vessels are spread, are disposed into numerous folds, so as to increase the extent of surface with which the water and its contained air come in contact. The apparatus for respiration in Insects, is a modification of the latter kind of structure: ranged along the sides of their bodies at regular intervals there is a succession of holes, which are the openings of a series of infinitely small tubes, extending in all directions through their interior; these openings and tubes conduct the air into their bodies, where it has the effect of purifying the blood. A higher form of respiratory organ is presented in branchiæ or gills. These are

possessed by such animals only as have the circulating system so far developed, that the elements of a heart, and a distinct set of vessels for conveying the blood to be oxygenated, appear for the first time; and they therefore indicate a greater concentration both of the respiratory organ and of the circulating system. But even gills pass through many gradations before they acquire that high degree of development with which we are most familiar in Fishes.

What we have chiefly to remark in all the modes of respiration hitherto mentioned is; first, that until we arrive at the order Fishes, the lowest of the Vertebrata, the Mouth has no connexion with the organ of breathing;—in all the Invertebrata, that aperture serves exclusively for taking in the food and manducation. Secondly, that it is in fishes, that we have the earliest example of an internal skeleton, in which is blocked out, as it were, the first rude form of a chest, for containing lungs, and for drawing in and expelling the air through a single tube, the trachea, or windpipe, communicating with the Mouth.

It may be new to many of the readers of this work to be told that the Air-Bladder, which serves in most fishes to accommodate their specific gravity to the various degrees of density of the water in which they swim, is, in reality, an elementary Lung. Yet that is proved to be the case by many facts in comparative anatomy. It is sufficient to state, that a set of fishes exist called Sauroid (from their resemblance to the inferior kinds of Reptiles), in which the air-bladder communicates with the mouth by a tube (termed ductus pneumaticus), which resembles, in all respects, a windpipe; and these fishes, when left on dry land, can respire by this apparatus, independently of their gills. The same structure passes through various gradations in other animals intermediate between fishes and reptiles, till the gills at length disappear, and the air-bladder becomes a more perfectly organized lung.

If we trace the progressive changes by which the sac, thus introduced for the first time into the interior of the body in communication with the mouth, becomes at length surrounded by an apparatus of ribs and muscles, capable, by alternate expansion and contraction, of drawing in and expelling air, we shall

find that the mechanism makes important advances towards a perfect form of that kind of respiration, in the order Reptiles. In the lowest of the order; those reptiles immediately above fishes, viz., Frogs and Tortoises—the development of ribs is so imperfect, that instead of the sac, or lung, being filled with air by an expansive motion of the thorax, it is gradually distended by successive actions of the Mouth, like swallowing: and Nostrils, through which the air is thus sucked, are now first perceived. In the higher reptiles, as the Crocodiles, the membranous sac becomes more compact, and like the proper substance of lung: it is permeated by numerous branches of the windpipe, which subdivide and terminate in air-cells: and the lungs are now for the first time surrounded by Ribs, and Sternum, provided with muscles to expand and contract the cavity. Although, in consequence of the weak, flexible structure of the bones of the chest (corresponding with the tortuous movements of the reptile in creeping) the process of alternate expansion and contraction is carried on imperfectly, the quantity of air received and discharged, small as it is, is sufficient for animals which are cold-blooded, and have a torpid circulation like theirs.

But however near an approximation is thus made, in reptiles, by the introduction of Nostrils, a Windpipe, and Lungs encased in a Thorax, to the apparatus of respiration as it exists in Man, a great change remains to be effected, before the resemblance is complete. Not only in reptiles, but in Birds, which is the order of vertebrata next above reptiles, the lungs occupy a part of the body common to them and the viscera generally: the thorax and abdomen form a single large cavity. It is not till we ascend to the Mammalia, the order above birds, and next to Man,—those vertebrate animals which have Lips, and can suck the teat—that a subdivision of the trunk into two distinct chambers, is found. That separation is accomplished by means of the Diaphragm, a muscular partition, which stretches across from the lower border of the ribs on one side, to that on the other. When that muscle is added, the lungs are closed in on all sides by moveable walls, capable of expansion and contraction; so that by enlarging the cavity, or inspiring, air is drawn freely into the chest; and it can

then be expelled, by expiration, with whatever degree of force is desired. In short, when the diaphragm is introduced, the organ of breathing attains its highest condition of concentration in the animal kingdom: and it is not only adapted in an admirable manner for oxygenating the blood, but for propelling the air along the windpipe, with such regulated force as is necessary to produce Vocal sounds.

When the chest has acquired the compact form presented in Man, several modifications in the structure of different parts of the frame, which do not at first appear directly related to breathing, take place. Accompanying the changes of mechanism, new sensibilities are also introduced, to guard the apparatus; and when these are excited, they have the power of animating numerous distant muscles to co-operate rapidly in producing the appropriate defensive actions. In order to understand properly the uses of the nerves distributed to the organ, it is necessary to bear those arrangements in view; and I may therefore direct attention to a few of them.

The first example may be taken from the act of Swallowing. We are so familiar with deglutition as an action performed in the same passage by which we receive our breath, that it does not seem remarkable, that food for nourishment, and air for respiration, should both be safely admitted by one entrance: and yet in about nine-tenths of the animal kingdom, namely, all the Invertebrata, the mouth is appropriated exclusively to taking in food, and has nothing to do with respiration. But let us suppose a morsel in the mouth, and trace its progress to the stomach. I only allude in passing, to the arrangement by which, when the mouth is full, and no air passes into the lungs by that inlet, it is provided that the breathing shall proceed uninterruptedly, by the Nostrils, which open into the throat behind, directly over the proper orifice of the windpipe. When the morsel has been chewed, and is ready for swallowing, it is propelled into the back of the mouth: and here it comes in contact with a part of the throat, which is endowed with a remarkable sensibility,—a sensibility of such a nature that, when excited, there is an irresistible desire to swallow; and the consequence is, that whenever the sensible spot is touched by the morsel, a large class of

muscles, consisting not only of those immediately adjoining, but of others situated at a distance, are brought into combined action, to grasp and propel the food rapidly into the gullet. Here a great variety of movements take place consentaneously. The windpipe is closed by its valve, the epiglottis, falling over it; the posterior nostrils are shut, by the folding upwards of the curtain, called the soft palate; certain strong muscles surrounding the upper part of the gullet compress the morsel, and urge it quickly past the opening of the windpipe, into that canal; but, before the food can reach the stomach, it must pass through muscular fibres of the diaphragm, encircling the gullet; these fibres consequently relax, and there is a momentary interruption of the regular action of the diaphragm. Now all these actions, which shew so remarkable a consent between the muscles of deglutition and of respiration, are excited and regulated by the peculiar sensibility seated at the back part of the throat. If, however, there should be any disturbance in the act of swallowing, and a small portion of the food should pass the wrong way, a different set of actions will occur, under the influence of another kind of sensibility; for example, if a crumb of bread should lodge in the throat, near the opening of the windpipe, a sensibility distinct from that which gives rise to swallowing, will be excited; and will rouse the muscles to produce a series of movements altogether different from the former: the same muscles which are at one time engaged in deglutition, will now be combined in such a way as to cause a succession of violent expirations, or fits of coughing, which will continue till the irritating particle is expelled from the top of the windpipe, and the danger of choking removed. So there are various other sensibilities seated in distinct parts of the passages, which differ in kind as well as degree, from those just mentioned; and, when these are excited, similar concatenated actions of the muscles are produced, modified according to the structure which requires to be cleared or defended.

I shall take the next example from the Circulating System. Comparative anatomy shews that, according as the apparatus of respiration becomes more perfectly organized, the heart and blood-vessels begin to be subdivided into two distinct systems;

the one for sending the blood to the lungs, and returning it when purified: and the other for distributing the purified blood to the body, and returning it for renewed oxygenation. That is the origin of the distinction drawn by anatomists, between the *pulmonic* circle, which includes the part of the heart and blood-vessels that belong to the lungs; and the *systemic* circle, or part of the heart and blood-vessels which send the blood over the body, and return it to the heart. This separation takes place in the animal kingdom, slowly and gradually, and is only complete in the warm-blooded animals. Thus, in man, the division of the circulating system appropriated to the lungs consists of cavities of the heart and of blood-vessels, quite distinct from those provided for propelling the blood over the body. Yet these two divisions act in perfect concert with each other; a concert mechanically secured by the peculiar structure of the heart; for the two sets of muscular cavities constituting the heart, are joined together, to form a single organ, and they contract in unison. Thus, so close a sympathy is established between the heart and the organ of respiration, that any interruption to the breathing, will not only affect the action of the division of the heart which belongs to the lungs, but it will also disturb the action of that part, joined to it in structure, by which the purified blood is conveyed through the body. Again, agitation of the heart, by disturbing the regular flow of blood to and from the lungs, will in like manner disturb the actions of respiration.

Another point, still connected with the Circulating system, deserves to be noticed, as throwing light on some of the questions treated in the work. The blood which returns to the heart by the veins, flows towards the chest in a slow and easily interrupted stream; the force which propelled it when issuing from the heart by the arteries, being exhausted before it enters the veins. From this weakness of the current, it follows that the blood collected in the great veins close to the entrance of the chest—as the jugular veins, for example—may be stopped by a slight cause; when congestion of the minute branches will be the consequence, and serious injury may be occasioned to the more delicate organs

from which the blood returns. Now there are certain conditions of the chest in breathing, during which the venous blood is thus interrupted. As we draw in the breath, the blood flows along the veins with perfect facility, because the superior opening of the chest is then enlarged, and the suction, which draws air into the windpipe, has also the effect of increasing the force of the current of returning blood. But when we expel the air, and thereby diminish the area of the chest, an obstruction takes place in the flow of blood in the veins, and if the act of expiration be strong, regurgitation may be produced. This interruption, and retrograde motion of the blood in the large veins of the neck, gorges the smaller vessels; an effect which may be seen in a person seized with a fit of coughing or of sneezing: for his face then becomes suffused with red, and the superficial veins turgid with blood. It is therefore obvious, that if the veins of the surface of the head become congested, in such violent conditions of breathing, the deeper veins, returning the blood from the Brain and the Eye, will also be over distended from the same cause. Consequently, the delicate textures of these important organs will be in danger of suffering serious injury from the loaded and turgid condition of the veins. But both organs are defended from such dangers by a beautiful arrangement of the muscles of the neck, which cover and protect the venous trunks. These muscles act in sympathy with the movements of respiration; so as to compress the large veins when the chest is contracted, and there is a tendency to regurgitation of the blood; and to take pressure off them, when the chest is expanded, and the channel to the heart is free. It is further to be noticed, that the flat web of muscular fibres which covers the eye—the orbicularis muscle, by which we wink, and shut the eyes—is a part of the same provision. It acts in compressing the eye-ball whenever the chest is violently contracted, as in coughing, &c.; by that means it closes the veins at the back of the orbit, and prevents engorgement of the fine branches which ramify on the delicate coats within the eye-ball.*

* The orbicularis muscle is wanting in animals which have not the same concentrated apparatus for breathing as man. I have shewn elsewhere that in man and mammalia another provision exists besides that mentioned in the text,

From all this it may be perceived by what close ties of sympathy the Circulating System and the Respiratory Organ are held together, when both are in the concentrated condition presented in Man. The heart acts upon the organ of breathing: and it, in its turn, is acted upon by the lungs. It is in this manner that the troubled motions within the breast, which sensibly accompany intense Emotion or Passion, exhibit themselves outwardly. Sudden changes of colour in the countenance denote disturbances in the heart's action; laboured, irregular movements of the chest, extending to the neck and face, mark interruptions to the action of the respiratory organ: and both give rise to the varieties of Expression. If in this agitated condition of the organ of breathing, Voice is exercised, it partakes the disturbance, and the words uttered carry an effect as if they came directly from the heart. Language then exerts its highest influence over the feelings of others.

It was from studying the human body with these views, that the author concluded:—that the nerves which arise from a part of the brain distinct from that which gives off the nerves generally, and which are distributed to the organ of Respiration, are bestowed in correspondence with the changes of mechanism which take place in that organ, and the new relations which are established between it and other parts, during its course of development in the animal kingdom. He believed that the main design of those progressive changes was to afford to Man an instrument suited to the superior endowments conferred on him:—to supply him with an organ for the communication

for guarding the eye against the irregularities of the venous circulation. The small veins which ramify in the interior of the organ between the delicate membranes that support the retina, join the larger trunks, before these pass out from the eye-ball, in a peculiar manner; each branch makes a circular sweep, so as to describe nearly a complete circle, previous to entering its principal vein, and being arranged in concentric circles, they produce an appearance whence the name *vasa vorticosa* has been applied to them. Nothing can be more admirably adapted than this structure for breaking the force of a retrograde current of blood, and gradually diffusing it over the membranes. A similar vorticose arrangement, though not so distinct, is observed in the superficial veins of the brain, and is obviously designed for a similar object.

of thought, and for thus exercising and evolving the powers of his Mind—that great attribute by which he holds his exalted position in Creation. But as for intercourse with his fellow-men, Man does not depend upon articulate language alone; there is the language of Expression; a mode of communication understood equally by mankind all over the globe;—not conventional, or confined to nations, but used by the infant before speech, by untutored savage visited by civilized European—he thought that the apparatus which was introduced for Voice and Language, was the same by which passion and emotion address themselves to us. Accordingly, he concluded, that the nerves of Respiration are at the same time the nerves of Expression.

Of these nerves, the “*Nervus Vagus*,” from its extensive distribution, and the importance of the organs which it supplies, must be accounted the most considerable. As its name implies, it takes a long, wandering course. Arising from the same part of the brain as the other respiratory nerves, it first gives branches to the back of the throat and posterior orifices of the Nostrils; descending a little in the neck, it sends a nerve to the upper part of the larynx, the organ of Voice; having passed further down, and entered the chest, a branch is reflected upwards, which goes, like the last, to the Larynx, but supplies its lower part; branches are next transmitted along the principal blood-vessels, to the Heart; while others, following the course of the bronchial tubes, enter the Lungs: the nerve having now expended nearly all its fibrils, descends along the gullet, and terminates in branches to that tube and the orifice of the stomach, where they are encircled by muscular fibres of the Diaphragm. The use of the nerve appears to be, to unite the various structures which have been enumerated, in sympathy; so that, although situated at remote distances, and for the most part intrinsically distinct in function, they may act in concert with the organ of respiration generally; and harmony may be established in the many complicated actions which they are associated together in performing. The “*Spinal Accessory*” nerve passes obliquely down the side of the neck, to supply muscles attached to the upper part of the chest and the shoulder-blades; and as these muscles co-operate with others in

expanding the chest, and assist also in preventing irregularities in the venous circulation during the excited conditions of breathing, it is concluded that the function of the nerve is to associate the muscles to which it goes, with the organ of respiration. The name of the next nerve in order, the "Glosso-pharyngeal," indicates the parts to which it is distributed, the Tongue, and the Pharynx, or funnel-like expansion at the back part of the throat, which forms the common opening of both the windpipe and the gullet: as it is here that the numerous complicated and finely arranged actions are performed by which the entrance into the air-tube is protected during deglutition, the glosso-pharyngeal nerve seems provided to regulate those actions, and connect them with the operations of the organ of breathing generally. The last nerve to be specially mentioned, is the "Portio-dura:" arising from the place of common origin of the respiratory nerves, and coming out in front of the ear, it sends branches first upon the side of the neck, to supply muscles which overlay and compress the veins in that part; it next gives nerves to the lips; afterwards to the nostrils; then to the orbicular muscle of the eyelids; lastly, to the muscles of the brows; and, in order to reach the parts of the face, to which it is destined, the nerve has to travel across the large masseter muscle, and the equally large temporal muscle, to neither of which (being muscles of mastication, and supplied by the Fifth nerve) does it give even the smallest branch: the chief use of the portio-dura is to associate the muscles of the Lips and of the Nostrils, the two external orifices of the air-tube, with the rest of the organ of respiration; but it fulfils other duties at the same time; its branches which descend upon the neck, and those which go to the orbicular muscles of the eyelids, control movements connected with disturbances in the venous circulation, produced in certain excited states of the respiration; while the whole nerve, in virtue of its commanding the motions of all the features of the countenance, is the great source of Expression in the Face.

Having shown the gradual process by which the organ of breathing is newly modelled, to adapt it to voice and expression, it is not out of place to point out how those other organs of the

body, which have been described as superintended by the "Original" class of nerves,—viz., the spinal nerves and fifth cerebral nerve—accommodate themselves to the new mechanism. It will be seen that, in the early stages of development of animals, owing to the defective organization of the Locomotive and Prehensile instruments, the Mouth is embarrassed by having to perform offices, connected with obtaining food, which preclude its being used as an orifice for breathing; it has consequently no connexion with the organ of respiration. But by degrees those subsidiary organs improve, free the Mouth from performing more duties than those of manducation, and it is converted, at last, into an opening which serves not only for receiving food, but for respiration, voice, and speech. As it is the adaptation of the size of the jaws, and of the cavity of the Mouth to Speech, which, according to the principles of the author,* impart the characters of nobleness and beauty to the permanent form of the human head, and distinguish it from the brute, I may briefly trace the steps in the development by which that is effected.

It was intimated before, that animals placed at the bottom of the scale of living beings, have an organization in many points resembling vegetables; nevertheless, those creatures possess an organ corresponding to the Mouth. But at that pristine stage of animal life, there are no distinct prehensile or locomotive organs to minister to the mouth; the "oral aperture" is little more than one of the stomata in the root of a vegetable, by which nutritious fluids are attracted from the soil. Take the example of the Sponges: fixed to a rock in the sea, the sponge cannot transport itself from place to place in search of food: it has no feelers or arms to procure nourishment; it is, in short, like a plant† in every respect but this, that instead of imbibing its food from the spot from which it grows, its numerous pores or mouths placed on the free surface of its body, receive the nutritious substances floating or dissolved in the water around it; the currents and undulations of the sea sweeping its pendulous body from side to side, and to and fro, compensate in some degree for

* Page 32.

† Whence the name, "Zoophytes."

the deficiency of locomotive and prehensile organs. Advancing higher in the scale, animals are met with still fixed to a rock, and wanting in locomotive organs; but the mouth is now provided with instruments corresponding to prehensile organs. Thus certain species of *Polypes*, attached to corals, exist, which have their open mouths surrounded by rows of tentacles or ciliary processes,* the principal use of which is to cause circles or eddies in the water near them, so that the nourishing matter in their neighbourhood may be attracted to their mouths, caught, and swallowed. In ascending a little higher, we find animals in general structure like those just described, having a mouth provided with tentacles capable of directing nourishing matter into it; but instead of these animals being fixed by moorings to a rock, they are let loose to float in the ocean; and we perceive, for the first time, indications of locomotive organs, combined with mouth and prehensile organs. The creatures to which I refer, are such as the "Sea-nettle." That animal consists of a mass of buoyant soft substance; by alternate contractions and expansions of its body, it has a slight power of directing its movements; but it trusts chiefly for its changes of feeding-ground to the effects of the tides and currents of the sea: like a boat without oars or rudder, it is drifted from sand-bank to sand-bank, and floating along passively, a prey to stronger creatures, and defended only by its stings, it picks up the food which casually falls within its reach; in short, its organs of progression are in the lowest stage of development. And here it may be remarked that it is in the ocean, lakes, or rivers, where we must look for creatures such as those described, which have their organs of prehension and of locomotion, and mouths, least advanced in organization: not only does the density of the water assist in buoying up their bodies and make them independent of solidly constructed members to rest or move upon; but the fluid divides or dissolves the nutritious matters, so as to be more easily received into their mouths of simple structure. Accordingly, when we ascend higher in the animal series, and arrive at those animals which possess the

* Like petals of flowers, whence the name, "sea-flowers."

earliest distinct representations of legs, such as belong to the highest, we perceive that the number of creatures capable of living on dry land begins to increase. I allude to animals which have an internal skeleton, that is, a skeleton composed of bones, met with first in the class Vertebrata. But amongst these the parts corresponding to legs and arms are, at the commencement, so imperfectly formed, that the animals to which they belong partly inhabit the water, and partly the land; and when they do visit the dry land, they crawl upon their bellies, that is, they assist their weak and slender extremities by the tortuous motions along the earth of their trunks and tails; as we see in the crocodile or lizard. Gradually, as the development proceeds, and the bones acquire increased solidity of structure, the body is well lifted up from the ground, the legs are longer levers, more powerful and more active, as we see in the condition of Quadrupeds.

Let us next observe the progressive advancement from the state of quadrupeds to that of Man. As the four-footed animals ascend in the scale, a contrast becomes evident between the power and dimensions of their *fore* and their *hind* legs. Originally, both these sets of members participated equally in sustaining the weight of the trunk and head, and moving the body; but, by degrees, the hind legs increase in size and strength disproportionately to the fore-legs; and the latter become possessed of freer and more diversified motion. In short, in the strong hind-quarters of the horse, deer, &c., we see a preparation for the parts corresponding to the lower extremities of Man, becoming the exclusive organs of progression; and in the light, agile forms of the fore-legs, a preparation for those corresponding to the upper extremities, taking on the part of arms, to act exclusively as instruments of prehension. But it is only in Man that this distinct appropriation of each member to its own peculiar function is found complete. The monkey, Man's nearest relation in the family of animals, can rest upon the hind legs; but only feebly and imperfectly; he can skilfully grasp a cocoa-nut with parts resembling human hands; but his so-called hands are still instruments of progression; they enable him to warp himself with agility along the branches of trees,

his proper habitation. Man is distinguished above all other animals by his lower extremities having solidity and power sufficient to sustain his body without the aid of other members, and so as to be his sole organs of progression: hence his erect position. Again, as man's upper extremities are emancipated from the duty of assisting in locomotion, they are free to execute whatever rapid and varied movements may be called for, either for self-defence or for procuring nourishment. And, in correspondence with that freedom of action, a *Hand* is added, which, for the perfection of its endowments and mechanism, has been, in all ages, a constant theme of admiration.

Now let us ask, what influence have the improvements thus shown in the construction of the organs of locomotion and of prehension, upon the structure of the Mouth? The chief use of the prehensile organs being to seize food for the supply of the mouth, it may be expected that, as they become more highly organized, the mouth will undergo a change in its form. What, then, is the effect of the improved organization of the prehensile organ, as seen in the hand of man, in allowing the mouth to be adapted for a vocal organ—an organ of Articulate Language?

It has been stated that in all the vertebrate animals below man, the member analogous to the arm and hand, is an instrument of progression as well as of prehension. Whether we take the fin of the fish, the anterior extremity of the reptile, the wing of the bird, the paddle of the dolphin, or the fore leg of the horse or dog, the principal, if not the only use of the member is to assist in locomotion; only a few quadrupeds, like the squirrel, the feline animals, &c., besides using their paws for running, climbing, burrowing, &c., employ them to carry food to the mouth. Now the consequence of using the organ intended to convey the food to the mouth as one for progression, will be, that the office of appropriating the food will be thrown upon the mouth itself. Accordingly, in all animals below Man, the mouth is a prehensile, as well as a manducatory organ. If the animal be graminivorous, it must crop the herbage with its teeth before chewing and tritulating it; if it be carnivorous, it must be provided with large, sharp fangs or tusks, to fight, seize, and tear its prey, before it can reduce its

food to a fit state for swallowing. In short, the mouth, with its delicate sense of touch, its hairs or whiskers projecting from it as feelers, and its jaws armed with large teeth, is to be looked upon, in conjunction with the long, flexible neck commonly belonging to brutes, as combining the functions of the human arm and hand, with that of an organ of mastication.

But it is obvious that a mouth of the large capacity and irregular shape of an animal like the horse, ox, dog, or lion, could never be adapted to produce articulate sounds. In a cavity such as the mouth of the horse, we can understand how neighing may be produced ; but we cannot suppose that, by any adjustment of the tongue or lips, the air, even if it were properly vocalized in the larynx, could be confined, and then be let suddenly free to give rise to explosive sounds ; or be impinged against the palate, to cause guttural sounds ; or be directed into the back of the nostrils, to produce nasal sounds. In short, none of those numerous, finely-varied changes in the shape of the interior of the mouth, produced by the combined action of the tongue, palate, cheeks, and lips, which give rise to the infinite modifications of sound in speech, could take place in such gross structures. For the vibrating air expelled from the larynx to be divided and modulated so as to produce words with proper tone and accent, it is necessary that the cavity of the mouth should be small, its boundaries regular and uninterrupted, and the communication between it and the nostrils, free.

Now that is the very character of the mouth in Man. Provided with an arm and hand, free to execute all the objects of his will, man is under no necessity to use his mouth as the brute does. Being limited as far as his food is concerned to mastication, the jaw-bones may be of small size and light construction, while the teeth may likewise be small, be set erect, and ranged in uniform, regular rows, so important for distinct articulation. On the whole, from the mouth being absolved, by the perfection of the *hand*, from performing more offices than those of mastication simply, the cavity admits of being diminished in size, the jaws and teeth of being reduced to moderate dimensions, and the whole form is suited in the most admirable manner to serve as an organ of articulate language.

On looking to the skulls of different races of mankind, it will be seen that nature, in fashioning the mouth of man to be a speaking organ, has not departed from her usual course of carrying on the process of development by slow and gradual steps. Observe the contrast between the skull of the Negro and that of the European, caused by the inordinately large size of the jaws and projection of the teeth in the former. The well-formed skull of the European is distinguished by having the jaws and teeth of comparatively diminutive size; while the cavities formed in the interstices between the bones of the face, at the brows and cheeks, and which communicate with the nostrils, to allow a free circulation of air around the chambers where sound is produced, being parts of the organ of Voice, are full and prominent.

Thus we perceive how the genius of the sculptors and painters of antiquity led them to discover a principle of beauty, in designing the human head, founded on a profound view of the relation existing between Man's physical structure and his mental constitution—the principle expounded in the first essay of this work. Regarding his supremacy over all created beings to be in virtue of his possessing a Mind, they looked for the signs of his superior organization, to those structures which minister most directly to the mind. The cranium was represented capacious and full, it being the part where the Brain, the seat of intellect, is lodged. But they studied, at the same time, the organ by which the operations of the intellect are embodied in Speech, and intercourse is established between the minds of man and man. The lower part of the face, including the jaws and teeth, which in brutes have such preponderating size to enable them to seize and rend their prey, was made small and delicate; while the upper portion, composed of passages and chambers permeated by the air, and accessory to the organ of Speech, was expanded and elevated into due dimensions, so as to give it characteristic prominence.

Thus, in whatever view we study the development of the animal frame, new proofs present themselves of the final aim of all the modifications which we successively trace, being to

confer upon man an instrument adapted to his intellectual nature—an organ of Speech. It is the fine adjustment of the various members of his body for that object, which renders his organization the most perfect in the animal kingdom. Additional strength is, therefore, given to the author's theory, that our conceptions of human beauty, both in regard to the form of the head, and the moveable features, have a direct relation to the fitness of the structures for Speech, Voice, and Expression.

Such is a brief account of the leading parts of the discoveries made by the author of the volume, in that important part of the anatomy of the body—the Nervous System. He first established that the nerves of Motion are distinct from those of Sensation ;—and that the nerves generally, possess different endowments, according to the divisions of the brain or spinal marrow from which they arise. He then arranged the nerves of the whole body into three distinct systems, corresponding with the organs which they respectively control. The First class is that composed of the Spinal Nerves and Fifth Nerve of the brain ; this class, he proved, bestows both motion and sensation on all the parts to which it is distributed ; and these parts, he further shewed, are organs which belong to man in common with the lowest creatures, their united function being to supply food, the first necessary want of all animals : he termed this set of nerves the “Original” class, and included in it the nerves of the various organs of the senses. The Second class comprises a series of nerves distinct from the former, both in their origin and mode of distribution ; they pass off from a circumscribed central portion of the nervous system, the medulla oblongata, and diverge to different parts of the head, neck, throat, and chest, already supplied by the original class : he shewed that these structures form together a mechanism for respiration, not found in the lowest animals, but gradually introduced by a slow process of development into the animal kingdom, till in addition to oxygenating the blood, it ultimately constitutes, in Man, the organ of Voice and Expression : to this set of nerves he applied the name, “Respiratory” class. In these two classes are combined together all the nerves which arise either from the Brain or Spinal

Marrow. The Third class consists of a series of nerves which have their centre in large ganglions, scattered principally among the viscera of the abdomen ; this forms the system called ganglionic or "Sympathetic:" and their use has been generally supposed to be, to unite in sympathy those organs by which the various organic functions are performed : such as secretion, absorption, assimilation of the food, the growth and decay of the body, &c. When the nerves belonging to these different classes are viewed, as by the anatomist, in their combined condition, crossing, joining, and interlacing, in the different parts of the body, nothing can exceed their apparent confusion ; but when examined by the aid of the principle, and the arrangement, introduced by Sir Charles Bell, order and design are found to pervade every part.

EXPLANATION OF THE PLATE.

NERVES OF THE FACE AND NECK.

I. Frontal or supra-orbitary branch of the fifth nerve of the brain, the terminating branch of the first or ophthalmic division : arising simply from the larger or ganglionic root of the fifth nerve, it bestows sensation alone.

II. Superior maxillary, or infra-orbitary branch of the fifth nerve, the terminating branch of the second division : arising simply, like the last, from the sensitive root, it bestows sensation alone.

III. Mental, or inferior maxillary branch of the fifth nerve : it arises from the third division : by referring to the wood engraving (p. 9) it will be seen that this branch comes simply from the sensitive root ; and it gives sensation alone.

IV. Temporal branches of the fifth nerve : they arise in common with the preceding branch, and bestow sensation alone.

V. This is the only branch of the fifth arising from the smaller or motor root, which appears superficially : it is called buccalis-labialis, from supplying the buccinator muscle, and muscles at the angle of the mouth ; and it associates these parts with the muscles of the jaws in mastication.

The branches of the motor root of the fifth which go to the more powerful muscles of the jaws, are situated deeply, and are not represented in the plate. Their distribution may be understood by looking to the wood engraving (p. 9.)

VI., VII., VIII., IX. These are spinal nerves ; the first of the series which come out, between the vertebræ, in the whole length of the spine, to supply the body generally with motion and sensation.

A. Portio Dura, or Facial Nerve : the motor nerve of the features. Arising from the medulla oblongata, close to the origins of the Nervus Vagus, the Glosso-Pharyngeal, and Spinal Accessory nerves, included in the respiratory class, it appears superficially

before the ear. In front of the ear, and while lying upon the two principal muscles of mastication, viz., the masseter and temporal muscles, it forms a web or plexus; but it gives no branch to any of the muscles of the jaws. Its branches pass off as follows:—

- a.* Frontal branches to the muscles of the forehead and eye-brow.
- b.* Branches to the eye-lids.
- c.* Branches to the muscles which move the nostrils and upper lip.
- d.* Branches to the lower lip.
- e.* Branches going down upon the side of the neck.
- f.* Connections with the Cervical Spinal Nerves.
- g.* A Nerve to the Occipital portion of the Occipito-frontalis muscle, and to muscles of the ear.
- B.* The Nervus Vagus, or grand respiratory nerve.
- c.* The Spinal Accessory Nerve.
- D.* The Ninth Nerve; motor nerve of the tongue.
- E.* Diaphragmatic Nerve.
- F.* Branch of the Sympathetic Nerve.
- G.* Superior Laryngeal Nerve, a branch of the Nervus Vagus.
- H.* Inferior or Recurrent Laryngeal Nerve, a branch of the Nervus Vagus.
- I.* Glosso-Pharyngeal Nerve.

THE END.

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